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METHODS FOR THE DEVELOPMENT OF SHIPBOARD HABITABILITY DESIGN CRITERIA. A REPORT ON SUBJECTIVE RESPONSE TO LIGHTING AND COLOR IN INTERIOR SPACE: A STUDY OF SHIPS' MESSING AREAS, AND FINAL REPORT FOR PERIOD ENDING MAY 31, 1974

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This report comprises two distinct parts. The first part bears the title, *A Report on Subjective Responses to Lighting and Color in Interior Space: A Study of Ships' Messing Areas.* This study investigates the perceptual and affective aspects of lighting and color applications in the messing areas of Navy ships by means of a literature survey and four experiments. The literature survey summarizes current work on the influence of color and lighting on the occupants of an interior space, and on the occupants perception of size, distance, temperature and weight. Following the survey,

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four experiments are described, in which Navy personnel evaluated slide views of a messing area simulated by a demountable scale model which was constructed to allow for variation in color scheme and lighting arrangement.

The second part of this paper is the *Final Report for Period Ending September 30, 1973*. It gives the rationale for the project on "Methods for the Development of Shipboard Habitability Design Criteria," examines methods for the identification of user requirements and their incorporation in the design process, describes strategies followed in the project with this objective in mind, and refers to the three specialized reports that summarize the main findings of the work done as part of this project from May 1, 1972 to May 31, 1974. The report also describes an experiment in which books of photographs of 27 environments were used as a vehicle to elicit responses from Navy personnel with respect to general impressions, color scheme, lighting, furnishings, and evaluations of appropriateness for specific use.

METHODS FOR THE DEVELOPMENT OF SHIPBOARD HABITABILITY DESIGN CRITERIA

A REPORT ON
SUBJECTIVE RESPONSE TO LIGHTING AND COLOR
IN INTERIOR SPACE:
A STUDY OF SHIPS' MESSING AREAS

and

FINAL REPORT FOR PERIOD ENDING MAY 31, 1974

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I. A Report on Subjective Response to Lighting and Color in Interior Space: A Study of Ship's Messing Areas

This study investigates the perceptual and affective aspects of lighting and color applications in the messing areas of Navy ships. The study first surveys the literature on how lighting and color in an interior environment affect the emotional responses of the occupants as well as their perception of size, distance, temperature, and weight. The paper then reports on four experiments in which Navy personnel evaluated slide views of a messing area simulated by means of a scale model, which was constructed to allow for variation in color scheme and lighting arrangement.

At present, most messing areas reflect a sameness of interior treatment that is repeated throughout the living and working areas of the ship. Typically, the color schemes are bland and the lighting inflexible. While the principle of using innocuous colors and lighting to avoid distracting effects might have some merit when applied to shipboard work space, it may well be inappropriate for messing areas, where encouragement of recreational and social activity is desired.

The present dullness and repetitiveness of Navy ship interiors can only exacerbate the monotony experienced by ship personnel, especially at sea, when they must live in a confined space for long periods. In fact, the importance of alleviating the visual monotony on shipboard has already been acknowledged by the Navy, as indicated by recent pilot projects in which the Naval Ship Engineering Center has specified innovative lighting and color applications for improving ship interiors (Castle, Saklem and Weiler, 1971).

As yet, however, our understanding of the affective and perceptual effects of interior lighting and color is too limited to provide specific guidelines for improvement. If we knew, for example, that certain arrangements of light and color significantly influenced a crew's perception of the size of a given area, then we could alleviate the feeling of confinement caused by low overheads and other spatial constraints. Or if we knew that certain combined attributes of light and color consistently and significantly influenced a crew's mood or their preferences among interiors, we could define design principles for anticipating user acceptance and satisfaction. Unfortunately, most investigations of subjective response to lighting and color have been limited to studies conducted in laboratories where specific variables could be studied under controlled conditions. Experiments with color have relied mainly on the presentation of small areas of color, usually samples of chromatic papers. But the effect of a color on a small area may be quite different from its appearance on a larger surface in a room, where the viewer is responding to many visual stimuli in addition to color. Also, while studies of subjective responses have provided some useful general guides, the variance in response between different groups tested suggests that this information should be used discriminately (Clarkson, Davies and Vickerstaff, 1950). Ideally, the data used in making decisions in design would be collected on subjects directly representative of the potential users.

LITERATURE SURVEY

The following review surveys the literature on the subjective response to light and color that would be of interest to ship designers. The material is conveniently presented under the categories "perceptive" and "affective" aspects of light and color.

Perceptual Aspects

One aspect of light and color which has been the subject of some debate is their ability to evoke a thermal response; that is, to make an interior

space feel warmer or cooler depending on the light sources or the color scheme used, thus contributing to the comfort or discomfort of the occupants. There is good general agreement in the literature that reds and yellows are the warmest hues, while greens and blues are the coolest. A study that linked the warmth or coolness of colors to hue association with chromatic objects found a maximum judgment of warmth for orange and a range of judgments of coolness through the greens and blues (Newhall, 1941). A thermal effect may result not only from surface colors, but from colored light sources as well. Even variations of the color temperature of white light may be responsible for the tendency to underestimate the actual temperature under bluish-white light and overestimate it under reddish-white light (Flynn and Segil, 1970).

The warmth or coolness of colors has long been thought to affect the apparent distance of surfaces from each other, and, consequently, the apparent size or proportions of an interior space. This theory is still embraced by many practicing designers, although recent studies indicate that it may be inadequate and even incorrect. In one rather elaborate experiment (Hanes, 1960), a room with moveable end walls was constructed. Subjects then mechanically adjusted different-colored end wall panels until the panels appeared equidistant from a standard gray wall. The results confirmed laboratory tests concluding that the reflectance of a color rather than its hue is responsible for the effect of colors on perception of distance, with light colors appearing closer and dark colors more distant. Under conditions where perspective is perceived, as in a room, this effect represents a relatively minor cue, however. In another study, a series of slides were made from a perspective drawing of a room interior in which the color scheme was varied by the application of chromatic papers on the wall surfaces (Küller, 1970). Observers indicated that the illusion of openness increased as the reflectance of the colors increased.

An earlier study found that the subjective response to brightness could be influenced by the color of light (Kruithof, 1941). For each color temperature of white light a maximum and a minimum agreeable level of illumination

on surface colors was found, above which the colors appeared unnatural and below which they appeared dim and cold. As the illumination is reduced, all colors appear less vivid, or lower in chroma. But since warm colors lose their chroma more readily than cool colors, darkening a room tends to make it look cold (Lynes, 1968). The relationship between color temperature, illumination and subjective agreeability is expressed in Kruithof's "amenity curve," which indicated that warmer or lower temperatures of white light are more acceptable when the illumination or general illuminance level is low.

When the illumination on a surface color is reduced, or when a surface color is seen in shadow, its appearance changes. Still, according to a study of reactions to color patches under varied illumination, one's judgment of hue, value and chroma is almost unaffected by the shadowing (Hopkinson, Gloag and Keyte, 1955). Colors seen in a strong highlight, however, cannot be judged so accurately, since the highlighting makes the colors appear considerably lighter.

The impression of spaciousness in a room is generally enhanced by higher levels of illumination or by colors of higher reflectance. A recent study of a room with flexible lighting arrangements suggests that the apparent size of an interior space may be expanded by increasing the luminance of one or more walls, using peripheral lighting, for example (Flynn, Spencer, Martyniuk and Hendrick, 1973). A Japanese study which evaluated the effect of windows on the perception of spaciousness in interior space concluded that the absence of windows can be counteracted by enlarging the room and increasing the illumination level (Inui and Miyata, 1971).

Color may also influence the apparent weight and size of objects. Objects of low reflectance appear slightly heavier than objects of high reflectance (DeCamp, 1917; Bullough, 1907); dark-colored objects also have been found to appear smaller than light-colored ones (Gundlach and Macoubrey, 1931). This information may be of particular interest to designers in selecting furniture or equipment for an interior space.

Because of the lack of information about the magnitude and significance of the various effects and about the implications of integration of color with the rest of the environment, there remain in most of these studies rather difficult questions of applicability. While the experiments have revealed some interesting clues about the perceptual effects of lighting and color, the designer should be cautioned to exercise discrimination in using such data as a basis for design criteria.

Affective Aspects

The affective aspects of color may be considered simply in terms of preference; that is, what color or combination of colors is preferred to another, or which are more pleasing than others in a given context. A summary of the data from many experiments which included over twenty thousand subjects indicated that there is a general preference for blue, followed by red, green and violet, with orange and yellow being least preferred (Eysenck, 1941). In ratings of color families, it was found that women rated warm colors higher, while men rated cool colors higher (Helson and Lansford, 1970).

Hue, or dominant wave length, is apparently the major determinant of affective response to single colors, although reflectance and chroma are also important. Chroma has been found highly significant in determining preferences, with more saturated colors preferred to the less saturated ones (Guilford, 1934; Helson and Lansford, 1970). With respect to lightness, colors of higher reflectance are preferred to those of lower reflectance.

The affective value of a combination of colors has been found highly dependent upon the affective values of the component colors (Geissler, 1917; Guilford, 1931). This relationship, however, is not based upon a simple summation of the component values, but involves other factors dependent upon the combination itself (Washburn, Haight and Regensburg, 1921). A comprehensive study on the effect of background colors on the pleasantness

of object colors under different light sources has provided over fifteen thousand pleasantness ratings for different combinations (Helson and Lansford, 1970). The strongest single requirement for pleasantness discovered in this report is the luminance contrast between object color and background color. Although data from this study is derived from responses to viewing small color chips, guidelines based on the results have been established for use by designers in choosing colors for interiors (Judd, 1971). Other evidence also indicates that very small or very large differences of hue in combination give more pleasing results than do medium differences (Allen and Guilford, 1936).

The matter of color harmony has produced numerous contradictions in opinion from one investigation to another. Although concluding that attempts to give simple rules for the construction of color harmonies are bound to fail, Judd offers a summary of generally accepted principles: "(1) Color harmony results from the juxtaposition of colors selected according to an orderly plan that can be recognized and emotionally appreciated. (2) Of two similar sequences of color, that one will be most harmonious which is most familiar to the observer. (3) Any group of colors will be harmonious if, and to the degree that, the colors have a common aspect or quality" (Judd, 1955).

Another affective aspect of color is its association with moods or emotional states. For example, the dominant surface color or composition of surface colors can make a space appear exciting, cheerful, depressing, or serene. Discrepancies in the results of studies in this area suggest, however, that there are limits to the reliability of predicting associations between colors and responses. Red is generally regarded as *exciting, stimulating, powerful* and *protective*. Blue and green seem to be *secure, tender, calm,* and *comfortable*. Black is seen as *distressed, despondent* and *defiant,* brown as *protective,* purple as *dignified,* yellow as *cheerful* and orange as somewhat *exciting* and *stimulating* (Wexner, 1954; Murray and Deabler, 1957; Schaie, 1964). It should be noted that as an illuminant, a color may suggest an entirely different mood than it does as a surface color. Red, for example, is considered *exciting* as a surface color, but as a general illuminant it is more likely to suggest *danger*. Similarly, green as a surface color is *relaxing,* but as a

general illuminant it can create a *sinister* effect. Magenta as a surface color is often considered *subduing*, but as a general illuminant it may be *dramatic* and *exciting* (Williams, 1965).

In order to further investigate this common belief that colors can induce emotional states, two studies examined the relationship between exposure to color and the electrical skin conductance of the observer (Wilson, 1966; Nourse and Welch, 1971). The experiments showed that the galvanic skin response increased with exposure to red and violet luminescent panels, but not to green. It was proposed that hues at the end of the visible spectrum might be more arousing than those located towards the middle. Earlier observations of neurotics and psychotics revealed that exposure to red light increased the "abnormality" of pathological behavior, while green light brought pathological behavior nearer to "normality" (Goldstein, 1942).

Interest even extends to the effects of light and color on physiology and health. For example, impulses from the retina can influence glandular functions, such as the inducement of gonad development and the secretion of certain hormones (Wurtman, 1968). In addition, results of direct action of light on the skin include stimulation of vitamin D production, skin tanning, and photolytic dissociation of bilirubin, a factor in combatting jaundice (Sausville, Sisson and Berger, 1972).

When the color rendition is important for critical examination of colored objects, a color rendering index (Nickerson and Jerome, 1965) may be used to evaluate the degree to which the illuminant renders objects in their "true" colors. However, when the main concern is for enhancing the appearance of colored objects, such as foods and complexions, another index would be more appropriate. Just such an index of color preference or "flattery," based on the way people prefer to see colors, is presently under consideration (Judd, 1967; Jerome, 1973). Preferred color rendering has been advocated in an argument for new flourescent white light sources composed of a mixture of blue-violet, pure green, and orange-red lights (Thornton, 1972). These new light sources apparently render the

colors of things as we prefer them to be, rather than as we usually see them, a capacity that is especially effective with skin color and food. Complexions and meat, for example, are preferred somewhat redder (less yellow) and more saturated, while green vegetables are preferred much greener (less yellow) and more saturated. By avoiding the blue-green and yellow light in the white mixture of the new sources and by emphasizing the preferred colors, the appearance of complexions, food, and so on should be enhanced.

Much controversy has centered around the subject of brightness contrast in interior space. Studies which indicated that best vision was achieved within the limits of a 3-to-1 ratio of brightness between the area of visual concentration and the surrounds have influenced the selection of lighting and color application in many interiors (Moon and Spencer, 1945). However, the effect of low contrast interiors has often been judged bland and uninteresting, and complaints about the aesthetics of this kind of ambience have been numerous. It is realized now that brightness differential within the visual field can give it interest, and contrast of illumination and surface brightness can establish a sense of visual direction and focus within a space.

Excessive brightness differential (glare) in an interior can, of course, be distracting, disagreeable, or even uncomfortable. The source of glare may be the illuminant of the space or a reflecting surface. The area and the location of glare and its brightness relative to one's adaptation all contribute to its effect. A Visual Comfort Probability Rating of a particular lighting system in a given space may be computed and expressed as the percentage of people who, if seated in the most undesirable location, will be expected to find the level of glare acceptable (Illuminating Engineering Society, 1972). Although closely related to glare, the quality of *sparkle* is a positive aspect of the luminous environment. Sparkle emanates from relatively small areas of brightness, providing the accent or highlight that lends vitality to a space.

In striving for visual interest and spatial definition, however, it may be advisable to avoid lighting arrangements that produce very wide variances in the intensity of illumination across a single room surface. Lynes (1968) suggests that very uneven illumination producing variations of brightness over a large color surface can create a sensation of gloom if the variations of brightness exceed the limits of brightness constancy; that is, the ability to perceive the brightness of a surface despite varying intensity of illumination. This ability enables one, for example, to recognize a white ceiling under low illumination as still being white, although it appears dark and gray. This effect holds over a certain range, depending on the color of the surface and the conditions of viewing.

A sensation of gloom may also be caused by other effects brought about by the failure of constancy in conditions of dim lighting (Lynes, 1968). As luminance decreases, the apparent brightness contrast between color values is altered so that the apparent contrast between grays and blacks decreases while the apparent contrast between grays and whites increases. Reduced illumination makes all colors appear lower in chroma. Also, when a room is darkened, subtle gradations of the modeling of large surfaces seem harsher. Modeling, which helps one to perceive the form and texture of an object, is a function of the distribution of light reaching the visible surfaces.

The perception of a surface involves pattern, texture and sheen, pattern being associated with the color of a surface and texture being associated with form. Perception of fine color pattern makes no special demands on lighting other than those necessary for good rendering of flat color. Percepion of texture, on the other hand, involves some degree of modeling, and is improved when sharper shadows are formed. Sheen occurs when light is reflected specularly from a surface, producing a blurred image of the light source. In the case of room interiors it is often desirable to reveal that a surface has sheen, but not to emphasize it to such an extent that the reflections are distracting.

As we have seen, the aesthetic and emotional effects of color and lighting are many, but for the designer, they remain areas in which he must rely mainly on his intuition, since design criteria have yet to be established.

EXPERIMENTS

The preceding review indicates 1) that further investigation is needed and 2) that if attempted, it should test responses to visual stimuli in the context of an interior space (a typical ship's messing area in this instance) and it should collect data from subjects representative of the user group (in this study, U.S. Navy enlisted personnel).

For convenience in eliciting user response to interior lighting and color applications, a messing space was simulated in scale model form. Previous studies of lighting applications have demonstrated the practicality of this approach (Rodman, 1970; Lemons and MacLeod, 1971). Also, a recent investigation of the validity of scale models in lighting studies that used comparisons with full-sized mock-ups showed acceptable correlations, although cautioning that the result of miniaturization may introduce an element of enhancement (Lau, 1972). In the present study, using a model allowed the investigators to obtain lighting and color variations which were reasonably representative of real interiors. Surface colors of bulkheads, decks and furnishings could be presented under normal influences of shadows, highlights, contrasts and accents. Slide views of the model were then used to test user response. The model (Fig. 1) represented a rectangular space 30 feet by 20 feet, with an overhead clearance of 6 1/2 feet--the dimensions of a typical destroyer messing area. A scale of 3/4 inches to 1 foot was selected as the most convenient size with which to work and still obtain the degree of detail required for realistic simulation. So that interior surface colors could be easily changed, bulkhead, overhead and deck elements were constructed of separate pieces which snapped together. The model was also furnished with tables and chairs, the colors of which could be changed.

Fig. 1: Model of destroyer messing space

Fig. 2: Photographing the model

For the most part, chromatic papers were used for surface colors.

A three-sided demountable enclosure (Fig. 2) was constructed to contain the model, as well as to exclude extraneous room light and to control the illumination on the model. It also served to support the 500-watt, 3200° K reflector floodlamps which were color balanced to type B color slide film. At first, two lamps were used, but the number was increased to six in order to provide additional lighting control. In the final configuration, the lamps were attached to a light stage with ball sockets, so that the lamps could be aligned or aimed as desired. Perforations in the sides of the light stage allowed it to be moved up and down to vary the illumination reaching the model. This feature was crucial for controlling the spread of the direct down light when it was used in the modeled environment. Each lamp was individually wired through a junction box, permitting any combination of lamps to be used. The insertion of baffles between the lamps assigned each lamp to a particular region of the modeled space.

The first overheads were of translucent plastic sheet to which was affixed a paper board with cutouts simulating a recessed fluorescent system. The final version consisted of three layers laminated together, and was designed to simulate perimeter, direct down, and general diffuse lighting. The bottom surface of the unit was finished to simulate a hung acoustic overhead with integral, recessed luminaires. The top layer was a sheet of translucent plastic which functioned as a diffusing medium for the perimeter and general diffuse simulations, and was perforated to allow for the down lights. Sandwiched between top and bottom surfaces was a layer of interchangeable opaque strips cut to match the openings of the ceiling luminaire pattern. Different combinations of strips generated the seven possible permutations of the three lighting types. The middle layer also allowed for the insertion of colored and neutral density acetate filters to model the varying intensities and color appearance of the simulated illuminants.

The presentation slides were taken early in the project with a 21mm f/3.8 lens, and were later improved with the acquisition of a 20mm f/3.5 lens.

High speed Ektachrome Type B film was used. The slides taken of the model appeared convincingly realistic when projected and compared well with slide views of actual ship interiors.

Slide views of the model were used in four experiments to elicit responses from the observers. In the first two experiments, the slides were projected in sets of three by three projectors onto three screens placed side by side. In the final two experiments, the slides were projected singly. The observers, all Navy enlisted personnel, viewed the slides in a room darkened to a level which allowed only for the completion of the questionnaires.

Experiment 1. The literature on perceptual aspects of color contains some agreement that the brightness of surfaces is a factor responsible for illusions of distance and space. On the strength of this, the first experiment employed achromatic color schemes, thereby isolating brightness from the other color attributes of color, hue and chroma.

A total of eleven different arrangements of color were used to produce seven sets of three slides each. In each of the sets the brightness of either the deck or the bulkheads was varied in each of the three slides, while all other surface reflectances were held constant. Three shades of gray were used to achieve high, medium and low relative brightness values of the variable surface in each set, and the constant surfaces between sets. Thus, in each set, the questionnaire (App. 1) required the fifty observers to make a judgment as to which scheme felt "most spacious" and "least spacious" from a presentation of three slides side-by-side, in which either the deck was the same reflectance value in each while the bulkheads were of high reflectance value in one, medium in another, and low relative reflectance in the third, or vice versa. In one set, only a single accent bulkhead located directly opposite the observer was varied. Examples of the schemes are shown in Fig. 3 and Fig. 4.

In each set of three slides, where the reflectance of the bulkheads remained the same throughout the three schemes while the reflectance of the

Fig. 3: Achromatic scheme for judgment of spaciousness

Fig. 4: Achromatic scheme for judgment of spaciousness

deck was varied, more observers judged the schemes with decks of relatively low reflectance to feel "least spacious" compared to schemes with decks of relatively high or medium reflectance (Table 1). In the sets where the reflectance of the decks remained the same throughout the three schemes, but the reflectance of the bulkheads was varied, there was no clear indication of influence on the perception of spaciousness. Neither was there an influence on the perception of spaciousness in a set of schemes where the reflectance of a single, end bulkhead was varied while all other surface reflectances remained the same. Schemes which included both decks and bulkheads of relatively high reflectance were consistently judged by more observers to feel "most spacious," while schemes which included both decks and bulkheads of relatively low reflectance were consistently judged by more observers to feel "least spacious."

Experiment 2. The second experiment was designed to determine whether there was consistency in the relationship between preferences and the pattern, the degree of chroma, hue contrast and reflectance differences of a color scheme (Table 2). Eleven sets of three slides were shown, with each slide presenting different arrangements of color and pattern on deck, bulkhead, partition, table and chair surfaces in the same messing area. The overhead was white in all arrangements except one. Each set of three slides illustrated variations on the same dominant scheme, the variations representing a relatively low, medium, and high presentation of chroma, hue contrast, brightness contrast, and/or pattern. While each set of slides was projected, the 51 observers selected the scheme they "liked most" and the scheme they "liked least." Munsell notations of the colors used in each scheme are listed in Table 3.

In nine of the eleven sets of three color schemes that were shown, more observers judged the scheme with relatively high hue contrast, reflectance differences, chroma and/or pattern "most liked," in comparison with schemes displaying relatively low or medium quantities. In the same nine sets, the observers judged the scheme with relatively low hue contrast, reflectance differences, chroma and/or pattern "least liked." In one set that differed

Table 1: Number of observers who judged achromatic color schemes of a simulated ship's messing area "most spacious" and "least spacious" in comparison sets of three, where the brightness of either deck or bulkheads was varied.

Deck		Bulkheads			
% reflection	relative brightness	% reflection	relative brightness	most spacious	least spacious
52	high	57	high	20	11
52	high	34	med.	10	8
52	high	18	low	19	29
				49	48
28	med.	57	high	17	19
28	med.	34	med.	11	8
28	med.	18	low	21	21
				49	48
14	low	57	high	24	12
14	low	34	med.	11	13
14	low	18	low	14	22
				49	47
52	high	57	high	18	5
28	med.	57	high	20	12
14	low	57	high	11	31
				49	48
52	high	34	med.	19	8
28	med.	34	med.	20	9
14	low	34	med.	9	31
				48	48
52	high	18	low	27	13
28	med.	18	low	13	10
14	low	18	low	10	26
				50	49
52	high	34,57	high	15	26
52	high	34,34	med	20	7
52	high	34,18	low	15	6
				50	49

Overhead was white (85% reflectance), tables and chairs were medium gray (34% reflectance), and lighting was constant in all cases.

Table 2: Number of observers who judged chromatic color schemes of a simulated ship's messing area "most liked" and "least liked" in comparison sets of three, where hue contrast, brightness contrast, chroma, and pattern of surfaces were varied.

scheme	relative hue contrast brightness contrast chroma or pattern	most liked	least liked
1-H	high	35	5
1-M	med.	15	1
1-L	low	1	45
2-H	high	29	11
2-M	med.	13	9
2-L	low	9	31
3-H	high	18	31
3-M	med.	25	3
3-L	low	8	17
4-H	high	27	17
4-M	med.	12	7
4-L	low	12	27
5-H	high	36	6
5-M	med.	13	0
5-L	low	2	45
6-H	high	23	15
6-M	med.	19	4
6-L	low	9	32
7-H	high	24	16
7-M	med.	22	6
7-L	low	5	29
8-H	high	11	17
8-M	med.	5	25
8-L	low	35	9
9-H	high	34	7
9-M	med.	12	9
9-L	low	5	35
10-H	high	38	0
10-M	med.	12	16
10-L	low	1	35
11-H	high	34	9
11-M	med.	8	2
11-L	low	9	40

Table 3: Description of schemes used in experiments 2 and 3, including Munsell notations of surface colors applied.

Scheme	Side Bulkhead	End Bulkhead	Partition	Deck	Chairs	Tables
1-H	10YR 8/10	2.5Y 5/6	2.5PB 4/10	2.5Y 9/2	2.5YR 4/6	5YR 7/12
1-M	10YR 8/10	10YR 8/10	2.5Y 5/6	2/5Y 9/2	2.5YR 4/6	5G 6/2
1-L	10YR 9/6	10YR 9/6	7.5YR 8/6	2.5Y 9/2	7.5YR 8/6	5G 6/2
2-H	10YR 8/2	2/5YR 5/12	10B 3/8	10B 5/10	N 0/0	dark wood
2-M	10YR 8/2	10YR 8/2	10B 3/8	10B 5/10	2.5YR 4/6	dark wood
2-L	10YR 8/2	10YR 8/2	10YR 8/2	10B 5/10	7.5YR 8/6	dark wood
3-H	5Y 9/2	5Y 9/2	5Y 6/4	2.5YR 5/12	N 0/0	10B 3/8
3-M	10YR 8/2	10YR 8/2	5Y 6/4	2.5YR 5/12	2.5YR 4/6	5YR 6/6
3-L	10YR 8/2	10YR 8/2	10YR 8/2	2.5YR 5/12	2.5YR 4/6	5YR 6/6
4-H	5Y 9/2	5RP 5/10	dark wood	5Y 6/4	2.5YR 4/6	7.5Y 7/4
4-M	5Y 9/2	5Y 9/2	5G 6/2	5Y 6/4	2.5YR 4/6	7.5Y 7/4
4-L	5Y 9/2	5Y 9/2	5Y 9/2	5Y 6/4	2.5YR 4/6	7.5Y 7/4
5-H	(2.5Y 9/2 &	7.5Y 7/4)		5Y 6/4	2.5YR 4/6	7.5Y 7/4
5-M	(2.5Y 9/2 &	7.5Y 5/6)		5Y 6/4	2.5YR 4/6	7.5Y 7/4
5-L	2.5Y 9/2	2.5Y 9/2		5Y 6/4	2.5YR 4/6	7.5Y 7/4
6-H	dark wood	dark wood		10B 5/10	N 0/0	dark wood
6-M	light wood	light wood		10B 5/10	N 0/0	dark wood
6-L	2/5Y 9/2	2.5Y 9/2		10B 5/10	N 0/0	dark wood
7-H	2.5Y 9/2	2.5Y 9/2		stripes	N 0/0	dark wood
7-M	2.5Y 9/2	2.5Y 9/2		10B 5/10	N 0/0	dark wood
7-L	2.5Y 9/2	2.5Y 9/2		10B 5/10	N 0/0	dark wood
8-H	2.5Y 9/2	2.5Y 9/2		checks	N 0/0	dark wood
8-M	2.5Y 9/2	2.5Y 9/2		stripes	N 0/0	dark wood
8-L	2.5Y 9/2	2.5Y 9/2		10B 5/10	N 0/0	dark wood
9-H	2.5Y 9/2	graphic		10B 5/10	N 0/0	dark wood
9-M	2.5Y 9/2	dark wood		10B 5/10	N 0/0	dark wood
9-L	2.5Y 9/2	2.5Y 9/2		10B 5/10	N 0/0	dark wood
10-H	2.5Y 9/2	2.5Y 9/2	pictures	10B 5/10	N 0/0	dark wood
10-M	2.5Y 9/2	2.5Y 9/2	murals	10B 5/10	N 0/0	dark wood
10-L	2.5Y 9/2	2.5Y 9/2	dark wood	10B 5/10	N 0/0	dark wood
11-H	graphic	graphic	graphic	10B 5/10	N 0/0	dark wood
11-M	graphic	2.5Y 9/2	graphic	10B 5/10	N 0/0	dark wood
11-L	2.5Y 9/2	2.5Y 9/2		10B 5/10	N 0/0	dark wood
12-C	5PB 6/6	5PB 6/6		10B 5/10	N 0/0	dark wood
12-W	5YR 6/6	5YR 6/6		2.5YR 5/12	N 0/0	dark wood

from this order (8-L), a monochromatic blue deck pattern was preferred by more observers than were either a high-contrast blue and white stripe pattern (8-M) or a blue and white checkerboard pattern (8-H). In the other set which differed from the order, a scheme which included table tops of high-chroma blue (3-H) was judged "least liked" by more observers than two schemes with less chroma and contrast.

Experiment 3. In the third experiment, 16 different color schemes were rated on preference, stimulation, appropriateness for dining and appropriateness for recreation (Table 4). Each of the nineteen observers was given the same weight in determining the results, through a normalization process which gave each person's data the same mean and standard deviation. The results were accumulated on the basis of how different the ratings were on a given rating scale for each pair of stimuli. The four sets of dissimilarities were then jointly analyzed by multidimensional scaling (Blasdel, 1972). A two-dimensional solution proved adequate to give a 0.96 correlation with the data.

Fig. 5 shows the information relating to the first dimension, which indicates the location of the schemes on the stimulus axis to the left, and the relevance of the different rating scales to that dimension on the axis to the right. The relevance axis shows that all the rating scales were related to the dimension, but that some of the responses to "appropriateness for dining" were not contained in the dimension. The spread of stimuli on the stimulus axis indicates that no one color scheme evoked an extreme response, and that the scheme provided for a range of quality.

Fig. 6 shows the same kind of information for the second dimension. The two dimensions are correlated, indicating that the two types of judgment are similar. The main difference appears to be in the shift of 11-H and, to a lesser extent, 6-H to a less desirable position. In this dimension the response relates to the appropriateness for dining. That all the rating scales were strongly related to a single dimension in Fig. 5 indicates that "stimulating" was thought to be both desirable and appropriate.

Table 4: Unnormalized subanalysis of the degree of preference, stimulation, appropriateness for dining, and appropriateness for recreation of sixteen color schemes.

PREFERFNCE	FREQUENCY BY RATINGS						
	1	*2*	*3*	*4*	*5*	*Average*	*S.D.*
Scheme 6-M	9	9	1	0	0	1.579	.591
Scheme 6-H	9	5	3	2	0	1.895	1.021
Scheme 6-L	5	10	4	0	0	1.947	.686
Scheme 11-H	8	5	2	2	2	2.211	1.360
Scheme 2-L	2	9	8	0	0	2.316	.653
Scheme 9-H	2	8	5	4	0	2.579	.936
Scheme 10-M	2	8	6	2	1	2.579	.990
Scheme 12-W	0	6	8	4	1	3.000	.858
Scheme 2-M	1	0	15	2	1	3.105	.718
Scheme 3-H	0	2	10	6	1	3.316	.729
Scheme 1-H	0	5	5	6	3	3.368	1.037
Scheme 5-M	0	2	8	7	2	3.474	.819
Scheme 3-L	0	3	6	6	4	3.579	.990
Scheme 8-H	0	2	5	8	4	3.737	.909
Scheme 1-M	0	2	5	7	5	3.789	.950
Scheme 1-L	0	0	2	5	12	4.526	.678

STIMULATION	FREQUENCY BY RATINGS						
	1	*2*	*3*	*4*	*5*	*Average*	*S.D.*
Scheme 6-M	6	9	4	0	0	1.895	.718
Scheme 6-H	8	6	4	1	0	1.895	.912
Scheme 6-L	4	11	4	0	0	2.000	.649
Scheme 11-H	2	9	4	4	0	2.053	1.234
Scheme 2-L	1	9	8	1	0	2.474	.678
Scheme 9-H	2	9	14	1	1	2.526	.939
Scheme 10-M	1	2	14	1	1	2.947	.759
Scheme 3-H	0	2	14	3	0	3.053	.510
Scheme 2-M	0	1	13	4	1	3.263	.636
Scheme 12-W	1	2	8	7	1	3.263	.909
Scheme 1-H	0	4	8	5	2	3.263	.909
Scheme 5-M	0	4	7	6	2	3.316	.921
Scheme 3-L	0	4	5	6	4	3.526	1.045
Scheme 8-H	0	2	6	7	4	3.684	.921
Scheme 1-M	0	1	6	8	4	3.789	.832
Scheme 1-L	0	1	0	6	12	4.526	.752

Table 4, cont.

APPROPRIATENESS FOR DINING	FREQUENCY BY RATINGS						
	1	*2*	*3*	*4*	*5*	*Average*	*S.D.*
Scheme 6-M	10	9	0	0	0	1.474	.499
Scheme 6-H	7	6	5	0	1	2.053	1.050
Scheme 6-L	3	11	5	0	0	2.105	.640
Scheme 2-L	4	8	5	1	1	2.316	1.029
Scheme 10-M	1	8	10	0	0	2.474	.595
Scheme 11-H	7	3	1	6	2	2.632	1.494
Scheme 9-H	2	4	8	3	2	2.947	1.099
Scheme 2-M	0	4	9	5	1	3.158	.812
Scheme 12-W	0	3	11	3	2	3.211	.832
Scheme 3-H	0	3	9	6	1	3.263	.784
Scheme 1-H	1	3	8	4	3	3.263	1.068
Scheme 3-L	0	5	8	1	5	3.316	1.126
Scheme 5-M	0	3	8	6	2	3.368	.871
Scheme 8-H	0	3	8	4	4	3.474	.993
Scheme 1-M	0	1	10	3	5	3.632	.930
Scheme 1-L	0	1	2	4	12	4.421	.878

APPROPRIATENESS FOR RECREATION	FREQUENCY BY RATINGS						
	1	*2*	*3*	*4*	*5*	*Average*	*S.D.*
Scheme 6-M	9	5	2	2	1	2.000	1.214
Scheme 11-H	8	8	0	1	2	2.000	1.257
Scheme 6-H	5	8	4	1	1	2.211	1.055
Scheme 6-L	3	9	5	1	1	2.368	.985
Scheme 2-L	3	7	7	1	1	2.474	.993
Scheme 9-H	1	8	5	3	2	2.842	1.089
Scheme 10-M	0	6	9	3	1	2.947	.825
Scheme 12-W	1	5	9	2	2	2.947	.999
Scheme 2-M	0	6	9	2	2	3.000	.918
Scheme 1-H	1	3	9	3	3	3.211	1.055
Scheme 5-M	0	4	7	7	1	3.263	.849
Scheme 3-H	1	2	8	7	1	3.263	.909
Scheme 1-M	0	3	8	4	4	3.474	.993
Scheme 3-L	0	4	5	5	5	3.579	1.091
Scheme 8-H	0	2	5	6	6	3.842	.987
Scheme 1-L	0	0	2	5	12	4.526	.678

Fig. 5

Like, Stimulating, Appropriate

stimulation, like/dislike
appropriate for recreation

appropriate for dining

Scheme 11-H
Scheme 6-H

Scheme 6-M

Scheme 6-L

Scheme 2-L
Scheme 9-H

Scheme 10-M
Scheme 3-H, 12-W
Scheme 2-M, 5-M

Scheme 1-H
Scheme 3-L

Scheme 8-H, 1-M

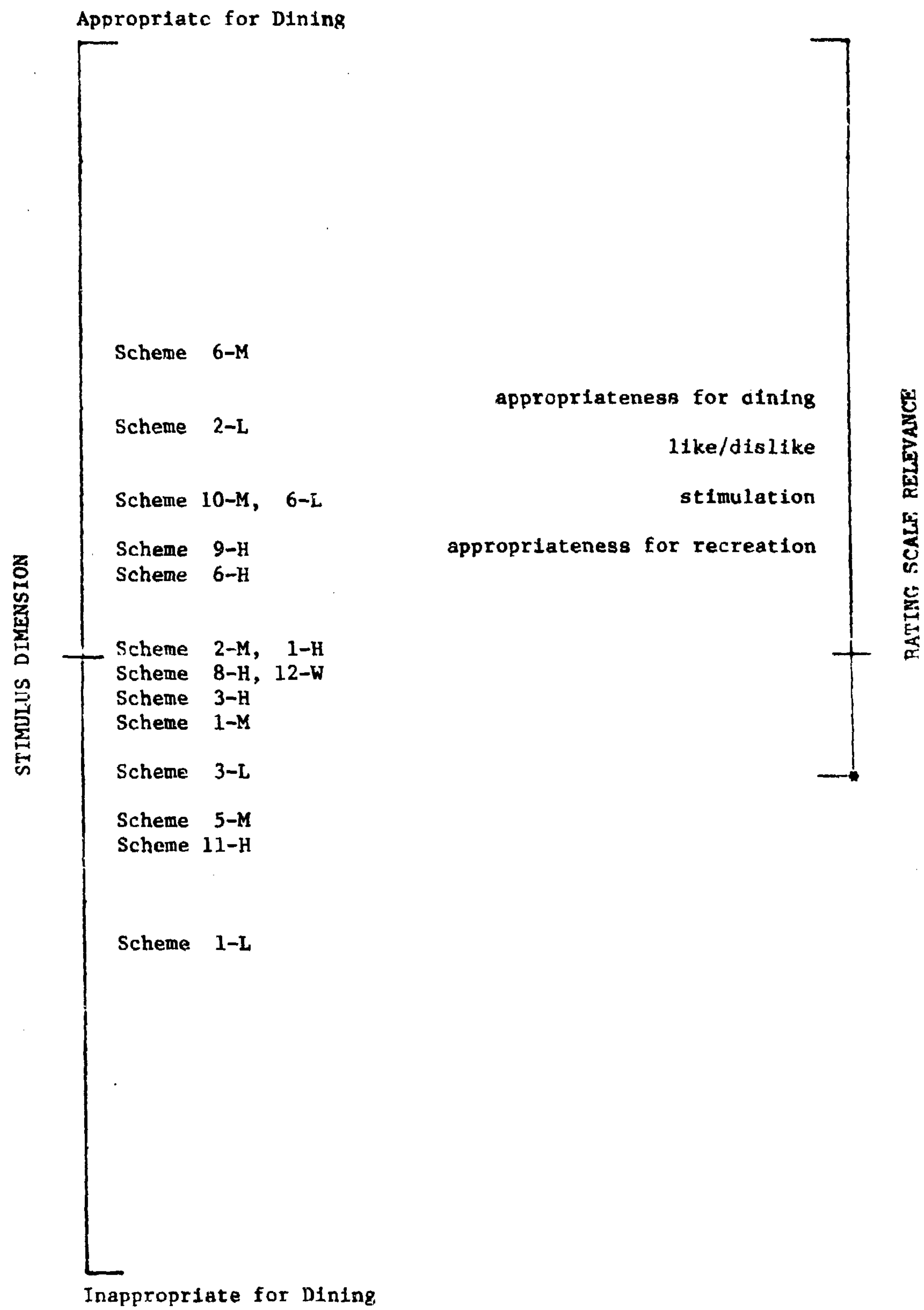
Scheme 1-L

STIMULUS DIMENSION

RATING SCALE RELEVANCE

Dislike, Unstimulating, Inappropriate

Fig. [illegible]


Appropriate for Dining
Scheme 6-M
Scheme 2-L
Scheme 10-M, 6-L
Scheme 9-H
Scheme 6-H
Scheme 2-M, 1-H
Scheme 8-H, 12-W
Scheme 3-H
Scheme 1-M
Scheme 3-L
Scheme 5-M
Scheme 11-H
Scheme 1-L
Inappropriate for Dining
STIMULUS DIMENSION
appropriateness for dining
like/dislike
stimulation
appropriateness for recreation
RATING SCALE RELEVANCE

The second dimension interjects a note of caution, suggesting that the scheme with the extreme application of supergraphics, including high chroma and contrast (11-H) is not appropriate for dining, and that the darker wood grain scheme (6-H) is somewhat less appropriate than was perceived in the first dimension. The other schemes received similar ratings on the two dimensions. In this analysis, the two dimensions appear to represent two different points of view in the same set of stimuli, with the second dimension representing, perhaps, the more conservative individuals.

In general, however, the wood grain bulkheads (6-H, 6-M) were very favorably regarded, although 6-H may be less appropriate with the darkness of the wood as the main distinction. Also, the wood grain table tops were common to all the favored schemes. Pattern on the bulkheads, whether in the form of graphics (11-H, 9-H, 10-M) or reveal-strip delineation (9-H, 6-H, 6-M, 6-L) or simply wood grained, was definitely favored. A scheme which featured alternating bulkhead panels of pale green and cream (5-M) ranked lower, however, probably due to a dominant green effect caused by a green deck in combination with the panels.

The schemes with blue decks (11-H, 6-H, 6-M, 6-L, 2-L, 9-H, 10-M, 2-M) ranked generally higher than the other colors. The only deck that was multicolored, a blue and white checkerboard pattern (8-H), ranked very low. The schemes with the brightest decks, a light beige (1-H, 1-M, 1-L), were not favored. Interestingly, the ranking of three related schemes (2-L, 2-M, 2-H) were reversed in this experiment over their order of preference in the comparison sets of the second experiment. This may be due to the similarity of color in the 2-L scheme to the favored wood grain scheme, a relationship that was not evident until the third experiment was rated.

<u>Experiment 4</u>. The final experiment was designed to test the effects of different lighting applications on the subjective response to interior space and various color combinations within the space. Whereas different

Table 5: Description by number of schemes used in experiment 4, including Munsell notations of surface colors applied, or nearest applicable notation for wood grain surfaces.

Bulkhead	WO				PO				W				WB				PB			
Chair	B		Y		B		Y		B		Y		B		Y		B		Y	
Deck	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Lighting: DPG	18	57			55	16			56					38			36	40 58	17	37
DG					14	53		33		34	15	54							19 35	
PD	24			43	3 39	5							4	23	44					25
PG	13	12 60	30		11	50		32	52	31						51				
G		29	7	20 49	28	48	8		6	9	27	10	26 59		46		45		47	
D					1	2	42		21		22							41		

Bulkhead	Hue	Value/Chroma	
WO - side bulkheads	10YR	5/6	(wood grain)
end bulkhead	5YR	6/12	(orange)
OP - alternate panels	10YR	5/6	(wood grain)
	5YR	6/12	(orange)
W - all bulkheads	10YR	5/6	(wood grain)
WB - side bulkheads	10YR	5/6	(wood grain)
end bulkheads	10YR	5/8	(blue)
PB - alternate panels	10YR	5/6	(wood grain)
	10B	5/8	(blue)

Chair

B - N 0/0 (black)

Y - 10Y 8.5/10 (yellow)

Deck

T - 10YR 7/6 (tan)

B - 10B 5/8 (blue)

Lighting

DPG - down, perimeter, general

DG - down, general

PD - perimeter, down

PG - perimeter, general

G - general

D - down

color schemes illuminated by a simulated, general fluorescent lighting system were presented in the previous experiments, this experiment included simulations of incandescent down floodlighting and perimeter cove lighting as well (Figs. 7-12). The systems were presented both individually and in combinations. Because of the typically low height of the suspended overheads, recessed installations of all three systems were simulated. The color schemes (Table 5) were selected to include varied amounts of wood-grain surfaces, since they had been preferred in the previous experiments.

In this experiment a set of 54 test environments in the form of projected color slide views were shown to groups of Navy personnel who responded to a set of questions about each test environment. The groups varied from five to twenty subjects for a single session, with each session lasting about three hours. In some cases the session was broken down into two shorter periods of 1 1/2 hours each, in order to relieve the monotony of one long session. The testing took place in varied locations, including ship libraries and Naval Air Station classrooms. Table 6 below shows the characteristics of the subjects participating in this experiment.

Table 6: Subjects for experiment 4.

		Paygrade				Yrs. Act. Duty		
Station	Respondents	E-4	E-5	E-6	E-8	2-4	4-8	8+
USS Enterprise	22	3	9	8		4	10	6
USS Mt. Hood	7		1	2	1			4
USS Niagara Falls	12							
Lemoore NAS	24	3	8	8	1	5	2	13
	65	6	18	18	2	9	12	33

Once the subjects were assembled for the session, they were given a personal biography form to fill out while the surveyor explained the purpose and procedure of the survey, mentioning that it was part of a habitability research project for ONR and that their responses to the slides of messing areas would be important input into the research. The questionnaires (Questionnaire No. 7, see App. 3) were then distributed while a group of sample environments were projected, so that questions about the procedure could be answered before the session got fully underway. The slides of the environments were then shown in random order for each group. The respondents were allowed about two to three minutes to fill in the questionnaire for each environment. During this time the surveyors circulated among the participants to answer questions and check that instructions had been properly understood.

The analysis was run only once, and the selection of subsets was made on the basis of a preliminary review of the possible meanings of the scales, therefore the data is not well "sorted out" and only partially represents the information which may be obtainable.

SUMMARY

In order to gain a better understanding of the perceptual and affective aspects of lighting and color applications in interior space, four experiments were conducted in which U.S. Navy enlisted personnel rated slide views of a variety of interior schemes produced by means of a scale model simulating a typical Destroyer messing area. The first experiment provided comparative evaluation of the feeling of spaciousness respective to brightness arrangements of achromatic color schemes for the purpose of determining whether control of color brightness could perceptually alleviate the feeling of confinement caused by spacial impingements and low overheads. The second experiment recorded preferences for relative degrees of hue contrast, chroma and/or pattern by comparisons within sets composed of three related schemes. In the third experiment, ratings

of preference, stimulation and appropriateness in response to various color schemes were scaled so as to produce an ordering of the schemes. The final experiment introduced the effects of different lighting applications in combination with various color schemes. Ratings were recorded on a number of scales grouped under general impressions, color schemes, lighting, and appropriateness for specific uses. Multidimensional scaling techniques of analysis were used to derive salient dimensions in each of the experiments.

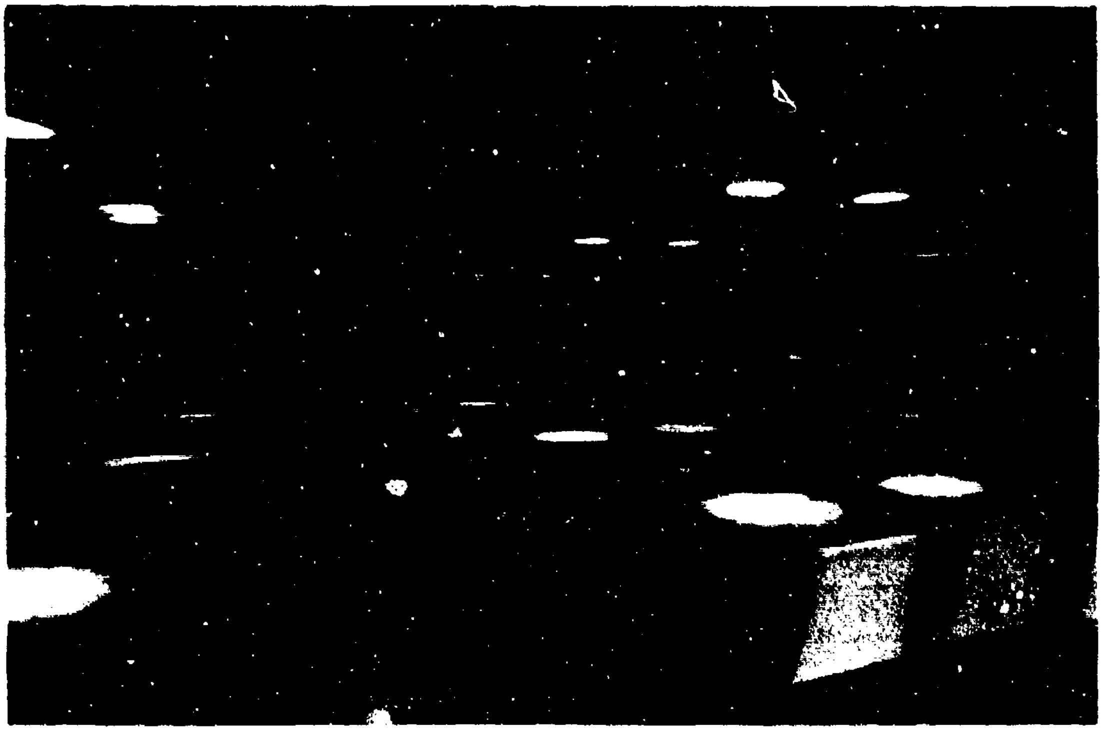


Fig. 7: Scheme 22, showing effect of down lighting only

Fig. 8: Scheme 8, showing effect of general lighting only

Fig. 9: Scheme 14, showing effect of down and general lighting together

Fig. 10: Scheme 43, showing effect of down and perimeter lighting together

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Fig. 11: Scheme 52, showing effect of perimeter and general lighting together

Fig. 12: Scheme 18, showing effect of down, perimeter and general lighting together

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MESSING FACILITY SLIDE EVALUATION FORM **NAME** ____________________

This study is sponsored by the Navy to improve habitability in living areas aboard ship. You will be shown slides of different color schemes for the same messing area in sets of 3.

While each set is being shown —

Mark a + in the box which represents the position of the scheme that feels <u>MOST</u> SPACIOUS and a − in the box which represents the position of the scheme that feels <u>LEAST</u> SPACIOUS

Example: 0.		−	+
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Mark a + in the box which represents the position of the scheme that you LIKE <u>MOST</u> and a − in the box which represents the position of the scheme that you LIKE <u>LEAST</u>

8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			

MESSING FACILITY SLIDE EVALUATION FORM NAME ____________

You will be shown 16 slides of different color schemes for the same messing area. First, they will be shown very quickly in order to acquaint you with the range within the group. Then, as each slide is reshown, mark your opinion of the color scheme across the categories.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LIKE																
like																
o.k.																
dislike																
DISLIKE																

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
STIMULATING																
stimulating																
average																
unstimulating																
UNSTIMULATING																

for dining:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
APPROPRIATE																
appropriate																
average																
inappropriate																
INAPPROPRIATE																

for recreation:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
APPROPRIATE																
appropriate																
average																
inappropriate																
INAPPROPRIATE																

QUESTIONNAIRE NO. 7

M E S S I N G   F A C I L I T Y   E V A L U A T I O N

This study is sponsored by the Navy to improve living areas on board ships. Fill out the evaluations listed on following pages by marking one point on each scale. The middle mark "Δ" means neutral or average and the marks further out indicate stronger opinion as shown below. Answer each question separately and try to use the whole scale. Try to find the most meaningful interpretation of each scale and use that meaning in your evaluations.

	good	good	good	average	poor	poor	poor	
good	o	o	o	Δ	o	o	o	poor
	very	somewhat	slightly	neutral	slightly	somewhat	very	

Evaluator____________

Environment____________

MESSING AREA EVALUATION

General Impressions	good	o	o	o	Δ	o	o	o	poor
	large	o	o	o	Δ	o	o	o	small
	dull	o	o	o	Δ	o	o	o	interesting
	jarring	o	o	o	Δ	o	o	o	soothing
	human	o	o	o	Δ	o	o	o	impersonal
Color Scheme	good	o	o	o	Δ	o	o	o	poor
visual impression	too plain	o	o	o	Δ	o	o	o	too gaudy
color coordination	well chosen	o	o	o	Δ	o	o	o	poorly chosen
walls to each other	well chosen	o	o	o	Δ	o	o	o	poorly chosen
furniture to room	well chosen	o	o	o	Δ	o	o	o	poorly chosen
decking to room	well chosen	o	o	o	Δ	o	o	o	poorly chosen
Lighting	good	o	o	o	Δ	o	o	o	poor
color of the light	good	o	o	o	Δ	o	o	o	poor
quality of the light	harsh	o	o	o	Δ	o	o	o	soft
distribution of light	good	o	o	o	Δ	o	o	o	poor
effect of the light	gloomy	o	o	o	Δ	o	o	o	faded
light fixtures turned on	good	o	o	o	Δ	o	o	o	poor
glare from lights	good	o	o	o	Δ	o	o	o	poor
glare from surfaces	good	o	o	o	Δ	o	o	o	poor
distribution of light	even	o	o	o	Δ	o	o	o	uneven
quantity of light	too much	o	o	o	Δ	o	o	o	too little
Evaluations									
for breakfast	appropriate	o	o	o	Δ	o	o	o	inappropriate
for lunch	appropriate	o	o	o	Δ	o	o	o	inappropriate
for dinner	appropriate	o	o	o	Δ	o	o	o	inappropriate
for reading/writing	appropriate	o	o	o	Δ	o	o	o	inappropriate
for card games	appropriate	o	o	o	Δ	o	o	o	inappropriate
for lectures	appropriate	o	o	o	Δ	o	o	o	inappropriate

your comments

____

____

II. Final Report for Period Ending May 31, 1974
Project on
Methods for the Development of Shipboard Habitability Design Criteria

The project reported here began officially on May 1, 1972, and was supported by the Office of Naval Research, Engineering Psychology Programs, Department of the Navy, under Task Order N00014-69-A0200-1058 (Work Unit Number NR 196-124).

The following five progress reports have been filed during the course of work on this project:

1. Progress Report No. 1, for the period May 1, 1972 to August 1, 1972, dated August 7, 1972;
2. Progress Report No. 2, for the period August 1, 1972 to November 1, 1972, dated November 10, 1972;
3. Progress Report No. 3, through February 1, 1973, and Final Report for First Funding Period;
4. Progress Report No. 4, through May 1, 1973;
5. Progress Report No. 5, for the period May 1, 1973 to August 1, 1973.

Some of the procedures followed in the project and some of the results have appeared in each progress report. Report Nos. 1, 2, 4 and 5 have received limited circulation, and as a result some of the material reported in them also needed to be included in reports receiving wider circulation, such as Progress Report No. 3 and this final report.

Three reports focusing on specific aspects of the project are scheduled to appear prior to or with this final report. They are as follows:

Technical Report No. 1: *Bibliography on Habitability with Abstracts*, October 1973, published separately;

Technical Report No. 2: *Multidimensional Scaling of Real and Simulated Environments*, May 1974, published separately;

A Report on: *Subjective Response to Lighting and Color in Interior Space: A Study of Shipboard Messing Areas*, included in this final report, July 1974.

The reader is urged to refer to Progress Report No. 3 and to the three specialized reports, in addition to this final report, for a comprehensive view of the project.

The following people have participated in the work done during the course of this project:

Sami Hassid, Professor of Architecture, Principal Investigator
Craig McArt, Assistant Professor of Design, Co-Investigator
Hugo Blasdel, Assistant Professor of Architecture, Co-Investigator
Elizabeth Bexton, Ph.D. Candidate in Architecture, Researcher
Harold Bexton, Ph.D. Candidate in Architecture, Researcher
Robert Hotten, M.Arch., M.L.Arch., Assistant Specialist
Denise Pourchier, M.Design Candidate, Research Assistant
Darryl Soon, M.Design Candidate, Research Assistant
P. David Steiner, M.Arch Candidate, Research Assistant
Henry Yu, M.Arch. Candidate, Research Assistant
Michael Stein, Graduate student in physics, Programmer
Gary Aufdenspring, Mary Ann Blasdel, Assistants
Ina Kau, Senior Typist Clerk
Vianne Ramirez, Senior Typist Clerk
Patsy Babbitt, Editorial Assistant
Linda Brubaker, Editorial Assistant
Phipps Arabie, Ph.D. Candidate in Psychology, Stanford University, Consultant on multidimensional scaling

Norman Cliff, Professor, University of Southern California, Consultant on multidimensional scaling

John Duddy, FHFS, Consultant on ergonomic aspects of furniture development

Merg Ross, Consultant on photography

Dr. Martin A. Tolcott, Director, Engineering Psychology Programs Office of Naval Research, was the scientific officer for the project

Mr. Robert Lawson, of ONR, Pasadena, was the regional coordinator for visits with Navy personnel.

The early portion of the project required the participation of Navy personnel at Treasure Island, and of volunteers from the Naval Training Station at San Diego, and involved the facilities of 24 Navy ships (see Progress Report No. 3, p. 3). In addition, later phases of the project have seen the participation of respondents selected from Navy personnel on the *Mount Hood*, at the Richmond Naval Base; on the *Niagara Falls* and the *San Jose*, at the Oakland Navy Supply Base; on the *Enterprise*, at the Alameda Naval Air Station; and on the *Flint*, at the Bethlehem Steel Shipyard; as well as personnel from the attack squadron at the Lemoore Naval Air Station.

In August 1973, Craig McArt left Berkeley to take a new position as Chairman of the Department of Design, College of Fine and Applied Art, Rochester Institute of Technology. In that month, Dr. Hugo Blasdel also left for Maryland, where he assumed the position of Assistant Professor in the School of Architecture, University of Maryland. Both had been working for two years on the project with Dr. Sami Hassid at Berkeley before leaving, but the last phases of the project, including the work needed for publication of this report was handled by Dr. Hassid, who kept in touch with the other two investigators.

Rationale for the Project

Issues pertaining to habitability cover a wide spectrum of areas of concern, but may be condensed into three distinguishable though interrelated

areas, namely:

1. Health and safety
2. Task performance
3. Pleasantness of the environment.

The first two areas have traditionally received adequate attention on the part of environmental designers. The Navy, in its role as provider of environments for specialized human activity, has followed the same tradition. However, in the formulation of criteria for habitability in these areas, there is little evidence of any conscious, systematic effort to utilize user responses as a guide for generating criteria, or as a basis for checking their appropriateness.

The importance of the third area is gradually gaining recognition as social awareness increases and as affluence raises the users' standards of expectation as to what constitutes a pleasant environment. Although this area is more directly related to user satisfaction, the general practice has been for designers to rely mainly on their own judgment. Recent pressures have created almost universal agreement on the need for designers to ascertain the preferences and norms of their clients, and more generally, of the users of the environments they create. However, little work has been done with respect to investigating ways in which this can be done, and little agreement exists on how the information may be used in the design process.

The Navy cannot escape the impact of demand for improved habitability, not only for the reasons operative in the civilian sector, but also because of the additional pressure of competition created by personnel recruitment and retention incentives needed under a system of all volunteer enlistment. As a result, there will undoubtedly be a need for substantial habitability improvements on board existing ships and for the inclusion of habitability criteria in the design phase of new ships.

As explained more fully in the initial proposal submitted to the Office of Naval Research[1] and more recently in Progress Report No. 3[2], this project was mainly oriented toward the development of methods for incorporating user responses into the process of generating and testing design criteria. The locales selected for testing consisted of messing areas aboard Navy ships, mainly destroyers; the respondents were Navy personnel volunteers.

Messing areas were selected as environments for testing partly because they are among the few spaces on board ship where nonduty related activities take place, and therefore where issues of habitability as perceived by the users take on added importance. By concentrating on a single type of environment, it was hoped that design variables could be tested systematically. At the same time, it was felt that of the various alternative spaces on board ships, messing areas offered possibilities for wider variations in design, thus allowing the investigation of a number of variables. Of course, the choice of specific messing areas and respondents was limited by the facilities and personnel available at the time they were needed by the research team.

Research Methods

A number of research approaches to habitability studies have been tried by others in the recent past, each making some contributions, but each having its own limitations. Rich areas of research include work on

[1] *System Development for Habitability Design Criteria.* Application to the Office of Naval Research, Psychological Sciences Division, by the Regents of the University of California, Berkeley, Department of Architecture; Principal Investigator: Sami Hassid, Professor of Architecture; Co-Investigators: Craig McArt, Assistant Professor of Design, and Hugo Blasdel, Acting Assistant Professor of Architecture. Duration of activity: May 1, 1972 to October 31, 1973.

[2] *Progress Report No. 3 through February 1, 1973 and Final Report for First Funding Period.*

health, material technology and engineering, the results of which have been incorporated into codes and specifications, such as the various Navy technical specifications. Other fruitful areas are human factors, human engineering, and environmental influences on productivity. In these areas, the designer's emphasis is usually on performance and efficiency in relation to specific tasks.

Difficulties arise, however, when criteria derived from technology and engineering are the sole scientific input into the design process. One reason is that such criteria are often established without the benefit of input from the users; another reason is that criteria usually deal with single dimensions or discrete elements, while environments are complex, involving many interwoven relationships.

Many attempts have been made to cope at least to some extent with these difficulties. They represent numerous points of view and may use consumer polls, survey techniques, questionnaires. observations, or anecdotal reports to obtain information on people's behavior, reactions, opinions, or expressed preferences in real environments. While these techniques may be helpful for some purposes, such as establishing product marketability, they have not been as successful in dealing with the complexity of real environments. In these, it is difficult to isolate attributes and to identify an adequate range of variation in the attributes to use in testing. When it comes to applying the results to design, further complications arise because a designer seldom produces exact replicas of the test environments, and prospective users can seldom adequately visualize that which is not yet built and real.

Some studies have used pilot projects in which a full-sized mockup of a space or a piece of furniture is built and tested in actual use to determine its performance, its flaws, and its degree of user acceptance. The Navy has followed this method in some habitability programs[3]. The method,

[3] J.E. Castle, A.A. Saklem and D.J. Weiler. *The Naval Architect's Role in Achieving Shipboard Livability*. Association of Senior Engineers Technical Symposium, 1971.

if properly incorporated in a master plan for research, may offer the best way for testing new ideas. A drawback is that ideas can be tested in only one combination in each experimental environment, so that the process of building up adequate data as a basis for design is necessarily slow. It is also prohibitively expensive to build a new pilot environment for every idea worth testing.

During the course of this project, the research team noted instances where crews were allowed to remodel certain spaces in the ship in accordance with their own preferences. This participatory design was found to raise the morale of the crew, by allowing the free expression of individual tastes and by stimulating a sense of pride in having shared in the conception of the design and in its translation into reality. In some instances, however, the result is that a portion of the ship, initially built to Navy specifications is literally torn apart and rebuilt to mostly nonconforming specifications, possibly endangering the safety of the crew. Tearing down an environment built to specifications and rebuilding it in a questionable fashion seems an unnecessarily costly way of creating user satisfaction.

With respect to habitability in ships, it appears that the Navy would need to go beyond engineering serviceability and job performance and into the satisfaction of human requirements. An ideal situation could be a system in which individual choice would be possible or even encouraged within the constraints of revised flexible criteria. Such criteria would insure health and safety standards, but, within a range of allowable alternatives, would allow room for the expression of user preferences. For the benefit of those who would ultimately make these choices, it would be useful to show them how they could go beyond simple conformity with Navy specifications into the exploration of concepts and the assessment of their worth.

This kind of attitude may also be useful to designers of other than Navy environments. Instead of simply complying with codes, ordinances and

technical specification, or designing simply according to their own concept of what constitutes a pleasant environment, they would have to find ways of assessing the worth and user acceptability of their plans.

The choice of ships' messing areas as a context for tests conducted in this project raised a number of considerations that needed to be taken into account. Since the living environment in a ship at sea is a highly confined environment, habitability research in such an environment could therefore draw upon research conducted in other confined environments, such as submarines, air raid shelters, space capsules, or other self-contained living modules. Most of this research usually relates to problems of survival and to behavior in stress situation and conflicts.

Our research team realized that in dealing with user satisfaction, it is not sufficient simply to look at life within the confines of the messing areas. Crew members bring with them norms and attitudes that are the result of their past experiences and background. Their reactions may also be affected by influences outside the environmental conditions in the messing area, such as anxieties concerning their career and security, or their relationships with crewmates and superiors--in short, all the problems people encounter when they are members of a group and of an institution. In a messing area, the mood of the crew may be influenced by irritants that have nothing to do with environmental attributes of the space, such as the type and quality of food served, or some incident in which the individual may have been involved.

Assuming that these difficulties can be overcome, or their effect minimized through appropriate research safeguards, and that research, when properly conducted, can reveal what may be accepted as a reliable expression of user preferences, a fundamental dilemma still faces the designer when a consensus does not emerge from the user' views, or when these are in conflict with his own notions and values.

In the business world, what is likely to sell usually dictates what is produced. Where tastes vary, the producer may accomodate by limiting production or by providing variations of the product to render it acceptable to each subgroup of need and expressed preference. But in the case of an environment destined to be used by groups of people with diverse preferences, the solution may call for a degree of arbitrariness as to whose views shall prevail, unless some sort of plurality decision system is devised.

Where the designer has control of decisions regarding the components of the designed environment, and where he is faced with conflicting user preferences, he may choose to ignore views not in harmony with his own, and follow what he considers the best course of action. Alternately, he may try to minimize the opposition by avoiding features eliciting strong negative reactions by some of the respondents, or he may resign himself to settling for a reasonably good design that may compare favorably with other forms of mediocrity when viewed by the users. Sometimes outstanding designs appear that possess universal appeal. The reasons for such appeal are hard to explain, but one may surmise that they are not the result of routine implementation of any recognized criteria.

Most Navy environments, however, are not in this category of outstanding and universally appealing design, and the designer should try to satisfy the largest number of users, even if this means that some conflict may develop between their preferences and his views. It is said that design conflicts are often the result of ignorance on both sides of the conflict, suggesting that better information may help both designers and users to come closer to agreement. This direction is espoused by exponents of participatory planning, in which users are encouraged to participate in the decisions affecting their environment. A similar concept is "argumentative design," in which different arguments are developed for or against key decisions. Issues are resolved on the basis of an accepted voting and weighting system, and by forms of gamesmanship in which members assume different roles to debate the issues.

Whatever system is used in the design process, and whatever ethical stand the designer takes to resolve the conflict between his professional and personal standards, and those of the users, the whole process would certainly benefit from knowledge about the nature and magnitude of the conflict. At a minimum, the designer should probably have information on average likes and dislikes with regard to the elements he manipulates, and a method for obtaining more accurate information about them and their implications for design.

Procedure

Progress Report No. 3 described the research strategies followed and the results obtained during the first funding period of this project--that is--from May 1, 1972, to February 1, 1973.

The activities pursued during that period included:

A bibliographic search for items relevant to the subject of habitability, and the preparation of abstracts for important items.

Field surveys aboard ships, to get acquainted with the environments of messing spaces and to obtain, on an informal basis, some initial crew reactions.

Experiments using slide views of existing ships, in which eleven sets of three slides were produced, one set for each ship visited in San Diego, and responses to questionnaires were obtained from 34 subjects viewing the slides of each set as they were projected side by side simultaneously on three adjoining screens.

Experiments utilizing real environments in actual use in which 38 volunteers were divided into four sub-groups and rotated around 13 ships in San Diego in 13 days, evaluating each day the messing space of the visited ship after eating the evening meal in it.

Experiments using slide views of models, in which slide views were produced from a demountable model simulating a typical messing area of a destroyer type ship. Three subexperiments were designed in which responses of subjects were used to test 1) the feeling of spaciousness, 2) preferences for variations of a dominant color, and 3) ratings in four categories of judgment.

Experiments using the input of design for multipurpose use of space, in which six concepts of multimode furniture were developed in mock-up form, and a two-dimensional scale model was used to illustrate furniture arrangement for alternate offtime uses of the messing space.

Investigations assessing the impact of the composition of respondent samples and of their attitudes, with one of the investigations dealing with the differences in ratings of messing spaces between crewmen and visitors, while the other dealt with the problems resulting from women's inclusion on shipboard.

Selecting the appropriate methods of analysis, in which rating responses were converted into matrices for multidimensional scaling, allowing the evaluation of dimensions of differences between environments for each rating scale.

The above research activities produced preliminary results which in some instances formed the basis for continued work. In some areas, the kind of additional research needed was judged sufficiently distinct from the main concern of this project to warrant its proposal under separate contracts, and therefore its termination under this project. The areas where such a course was followed include "the input of design," the "impact of crew composition and attributes," and "the inclusion of women aboard ship."

Under "the input of design," the results included the development of technical criteria for the evaluation of the six concepts proposed for multimode furniture, and an evaluation based on these criteria.

Certain conclusions were derived from the study of the "impact of crew composition and attributes," including the finding that responses from a group of visitors similar in composition to the actual crew using the space provide a more reliable input than those of the crew itself for the study of environmental characteristics, except where at sea conditions come into play.

The study of the subject of "the inclusion of women on board ship revealed certain habitability needs and preferences expressed by women, and indicated that a heterosexual environment would help create a better atmosphere aboard ship, although some parts of the ship need to be reserved for the exclusive relaxation of each sex during off duty hours.

The areas in which the preliminary results obtained during the first funding period formed a basis for continued work with this project included the "bibliography," "multidimensional scaling," and "slide views of models." Two progress reports (Nos. 4 and 5) contain descriptions of work done during the renewal period. Again, because of the limited circulation of these reports, their content is reviewed in this final report and in the three specialized reports issued concurrently. An additional area of investigation was attempted during the renewal period, utilizing books of photographs of messing spaces, and the results of this work are also reported here.

Bibliography. During the renewal period, the collection of items was updated and completed. The entries collected fell under various subjects of interest to the focus of this project and to the more general field of habitability. Abstracts for important items were prepared. The results are appearing concurrently with this final report in a technical report entitled *Technical Report No. 1: Bibliography on Habitability with Abstracts*. The report has nine chapters, all typeset, with some subsections. Each chapter has an introductory text explaining the reasons for inclusion in the project, and the major contributions in the subject matter.

The bibliography has been organized into the following chapters:

- Chapter I: Multidimensional Scaling
- Chapter II: Single Attribute Scaling
- Chapter III: Perception, Modeling Techniques
- Chapter IV: Small Group Interaction
- Chapter V: Subjective Responses to Color
- Chapter VI: Seating Comfort
- Chapter VII: Noise
  - a. Physiological Responses to Noise
  - b. Effect of Noise on Human Performance
  - c. Surveys of Responses to Noise
- Chapter VIII: Light
  - a. Light Calculations
  - b. Glare Control
  - c. Responses to Light
- Chapter IX: Thermal Environment

<u>Multidimensional Scaling</u>. One of the main problems addressed in this project relates to methods for the development of appropriate criteria for the evaluation of environments. All man-made environments have a number of simultaneous attributes, each of which may influence the user's response to a varying degree under given circumstances. In environmental evaluation, it is not sufficient to consider each attribute independently and to apply criteria based on fulfillment of certain requirements in a linear fashion along each attribute.

In *Progress Report No. 3*, some preliminary results were included, explaining the reasons behind the adaptation of Carroll and Chang's model for multidimensional scaling and its use in the analysis of data collected in this project. During the renewal period, this aspect of the project received considerable additional attention. Results of this work have been reported in *Progress Reports No. 4* and *5*, and are included in a separate technical report scheduled for completion concurrently with

this final report under the title: *Technical Report No. 2: Multidimensional Scaling of Real and Simulated Environments.*

The report is divided into six chapters. Chapter I investigates alternative approaches to environmental scaling, including averaging, factor analysis, single-matrix multidimensional scaling and multi-matrix multidimensional scaling, and compares the advantages of the latter over other methods. Chapter II explains the mathematical basis for the multidimensional scaling procedure selected for use in scaling environments.

Chapter III reports a Monte Carlo study of INDSCAL conducted with simulated rating scale data, in which random data was generated, error was added, and indications of significance and fit were obtained.

The last three chapters give some illustrations of experimental design, data analysis and procedures for shipboard messing area evaluation. The study as a whole shows that the method followed in the project may prove useful in the identification of potential attributes, and in highlighting significant dimensions for the subjective evaluation of environments with considerable accuracy.

Slide Views of Models. The three experiments using slide views of models that were conducted during the first funding period were described in *Progress Report No. 3.* Results obtained suggested that additional work might be pursued in the renewal period, in which slide views of models would be used, but in which variations in color schemes and lighting patterns would be investigated.

The work done in this area is reported in the first part of this joint report under the title *Subjective Response to Lighting and Color in Interior Spaces, A Study of Ships' Messing Areas.*

The report reviews the literature concerning perceptual aspects and affective aspects of color, and describes the four experiments conducted

in this project and the results obtained in each of them. Slides used in these experiments were produced by photographing a simulated interior of a destroyer messing space. The simulation consisted of a demountable model placed inside a light box, the design of which was improved during the renewal phase to allow simulations of a variety of color schemes and of lighting systems to be introduced.

Using the slide views illustrating variations in the design features of the simulated messing space, responses were elicited from Navy personnel with respect to general impressions, color schemes, lighting, and appropriateness of specific uses.

Photographs of Messing Spaces. In the early phases of this project, slide views were produced for the messing spaces of a number of ships visited by the research team. These slide views were used to elicit responses from crews in addition to their responses to actual environments, as reported in the Final Report for the First Funding Period.[1]

During the last stages of this project, an attempt was made to experiment with another method of presenting the information to the respondents for their reactions. Photographic enlarged color prints were made from selected slides produced and used in early stages of this project. These photographs were bound into books in which each page, identified by a stimulus number, contained three views of a ship's messing area. Twenty seven environments were illustrated in this manner in each book, and the sequence of environments was varied from one book to another.

In the earlier stages of the work, a special questionnaire[2] was used to elicit responses when three slide views of each environment were simultaneously projected on adjacent screens. Some modifications were introduced in this questionnaire to produce Questionnaire No. 8 (See Appendix)

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[1] *Progress Report No. 3, Through February 1, 1973, and Final Report for the First Funding Period.*

[2] See Questionnaire No. 2, in *Progress Report No. 3, op. cit.*

for use in the later phases. Responses to the environments illustrated in the books of photographs of messing areas were recorded on Questionnaire No. 8 by Naval personnel on the *Mount Hood* at the Richmond Naval Base; the *Niagara Falls* and the *San Jose*, at the Oakland Navy Supply Base; and the *Flint*, at the Bethlehem Steel Shipyard.

Because of limitations of time and resources during the last stages of the project, it was necessary to limit the analysis of collected data within feasible boundaries, with consequently fewer results than could potentially be derived from the available information.

SUMMARY

The project on *Methods for the Development of Shipboard Habitability Design Criteria*, which was supported by the Office of Naval Research, Engineering Psychology Programs, was conducted at the Department of Architecture, University of California, Berkeley, from May 1, 1972 to May 31, 1974. The work conducted during this period was reported in five progress reports in addition to this Final Report. Three specialized reports, published concurrently, deal with *"Bibliography on Habitability with Abstracts", "Multidimensional Scaling of Real and Simulated Environments", and "Subjective Response to Lighting and Color in Interior Space: A Study of Ships' Messing Areas"*.

Twenty nine ships and a Naval Air Station were visited during the course of this project, providing messing spaces as test environments, or personnel as respondents. The project's objectives were mainly aimed at developing methods for incorporating user responses into the process of generating and testing design criteria. These objectives led to a sustained literature search, to the development of methods for communicating design variables to respondents, for collecting data appropriately distributed over scales of measurement, and for analyzing the data through procedures applicable to the interrelatedness of simultaneous multiple attributes.

A number of experiments were designed and conducted in this project. They involved field surveys, reactions to real environments in use, the use of slide views of existing messing spaces aboard ship, the use of slide views of models of interior spaces illustrating variations in color and lighting, the development of multi-mode furniture as a vehicle to study the input of design, and investigations relating to social factors such as the composition of respondent groups and the inclusion of women on board ship. A comprehensive account on most of these activities appeared in the *Final Report for the First Funding Period* published in February 1973.

The three main directions of the work completed in this project are described in the three specialized reports. The *bibliography* report includes nine chapters, each with an introductory text, followed by entries with abstracts for important items. The *multidimensional scaling* report reviews the literature on environmental scaling, explains the mathematical basis for a multidimensional scaling procedure adopted from Carroll and Chang's model, reports on a Monte Carlo study of INDSCAL with simulated rating scale data, and illustrates the application of the technique to shipboard messing area evaluation.. The *lighting and color* report reviews the literature on perceptual and affective aspects color, and describes four experiments utilizing slide views of a simulated interior of a destroyer messing space. The demountable model placed inside a light box was used to produce slides allowing simulations of a variety of color schemes and of lighting systems.

A final phase of the project utilized books of color photographs of 27 environments as a vehicle for presenting the information on messing spaces to respondents.

Results obtained in each of the experiments are included in the respective reports mentioned above. The literature search yielded a large body of information relevant to the subject matter of this project. The various techniques utilized to simulate real environments offer

realistically efficient ways of eliciting responses to visually perceived environmental variables. The multidimensional scaling technique of analysis developed in this study is an efficient and powerful tool for environmental evaluation. The application of the developed methods to the study of color and lighting variables has proved effective, and has yielded limited results due to inadequate time for appropriate computer analysis and interpretation.

QUESTIONNAIRE NO. 8

M E S S I N G   F A C I L I T Y   E V A L U A T I O N

This study is sponsored by the Navy to improve living areas on board ships. Fill out the evaluations listed on following pages by marking one point on each scale. The middle mark "Δ" means neutral or average and the marks further out indicate stronger opinion as shown below. Answer each question separately and try to use the whole scale. Try to find the most meaningful interpretation of each scale and use that meaning in your evaluations.

	good	good	good	average	poor	poor	poor	
good	o	o	o	Δ	o	o	o	**poor**
	very	somewhat	slightly	neutral	slightly	somewhat	very	

EVALUATOR____________

ENVIRONMENT NUMBER____

MESSING AREA EVALUATION

General Impressions	good	o	o	o	Δ	o	o	o	poor
	large	o	o	o	Δ	o	o	o	small
	dull	o	o	o	Δ	o	o	o	interesting
	jarring	o	o	o	Δ	o	o	o	soothing
	human	o	o	o	Δ	o	o	o	impersonal
	clean	o	o	o	Δ	o	o	o	dirty
	modern	o	o	o	Δ	o	o	o	dated
	well arranged	o	o	o	Δ	o	o	o	poorly arranged
	similar to experiences	o	o	o	Δ	o	o	o	dissimilar
	good photographs	o	o	o	Δ	o	o	o	poor photographs
Color Scheme	good	o	o	o	Δ	o	o	o	poor
visual impression	too plain	o	o	o	Δ	o	o	o	too gaudy
color coordination	well chosen	o	o	o	Δ	o	o	o	poorly chosen
walls to each other	well chosen	o	o	o	Δ	o	o	o	poorly chosen
tables to room	well chosen	o	o	o	Δ	o	o	o	poorly chosen
chairs to room	well chosen	o	o	o	Δ	o	o	o	poorly chosen
decking to room	well chosen	o	o	o	Δ	o	o	o	poorly chosen
surface textures	well chosen	o	o	o	Δ	o	o	o	poorly chosen
Lighting	good	o	o	o	Δ	o	o	o	poor
color of light	good	o	o	o	Δ	o	o	o	poor
quantity of the light	good	o	o	o	Δ	o	o	o	poor
distribution of the light	good	o	o	o	Δ	o	o	o	poor
quality of the light	harsh	o	o	o	Δ	o	o	o	soft
effect of the light	gloomy	o	o	o	Δ	o	o	o	faded
fixture type	good	o	o	o	Δ	o	o	o	poor
fixture arrangement	good	o	o	o	Δ	o	o	o	poor
overhead surface	good	o	o	o	Δ	o	o	o	poor
glare from the lights	good	o	o	o	Δ	o	o	o	poor
glare from surfaces	good	o	o	o	Δ	o	o	o	poor
distribution of light	even	o	o	o	Δ	o	o	o	uneven
quantity of light	too much	o	o	o	Δ	o	o	o	too little

EVALUATOR ______________

ENVIRONMENT NUMBER _____

Furnishings	good	o	o	o	Δ	o	o	o	poor
seating type	good	o	o	o	Δ	o	o	o	poor
table type	good	o	o	o	Δ	o	o	o	poor
table arrangement	good	o	o	o	Δ	o	o	o	poor
space in arrangement	generous	o	o	o	Δ	o	o	o	cramped
effect of arrangement	cluttered	o	o	o	Δ	o	o	o	orderly
Evaluations									
for breakfast	appropriate	o	o	o	Δ	o	o	o	inappropriate
for lunch	appropriate	o	o	o	Δ	o	o	o	inappropriate
for dinner	appropriate	o	o	o	Δ	o	o	o	inappropriate
for reading/writing	appropriate	o	o	o	Δ	o	o	o	inappropriate
for card games	appropriate	o	o	o	Δ	o	o	o	inappropriate
for social events	appropriate	o	o	o	Δ	o	o	o	inappropriate
for lectures	appropriate	o	o	o	Δ	o	o	o	inappropriate

Your Comments: ____

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